Technology and RDT&E – An ARMY Perspective

United States Army & United States Air Force

ENERGY FORUM

Power the Force. Fuel the Fight.

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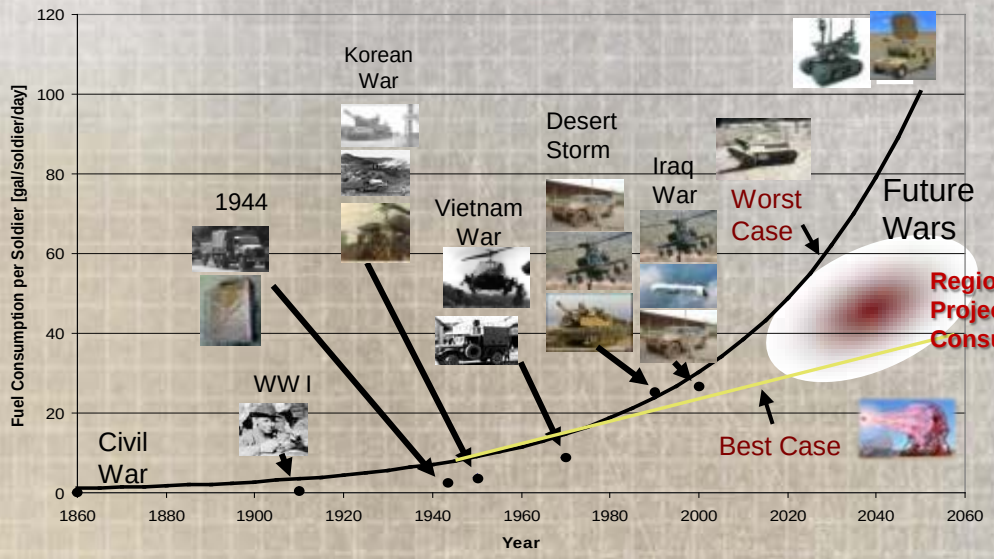
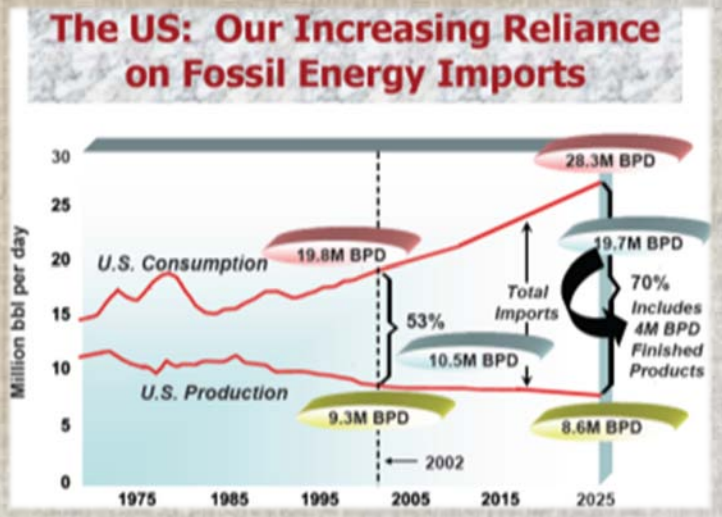
Ground Vehicle Power & Energy Trends

The Challenges

- **Battlefield consumption of energy increasing**
  - New C4ISR technologies
  - IED Defeat Systems
  - Added Armor and Weight across all platforms
- **Energy security problematic**
  - Increasing dependence on foreign oil
  - Alternative sources sought – wind, solar, bio-mass, waste to energy
- **Operational issues**
  - Battery usage & limitations – energy & power density
  - Demand for auxiliary power on-board vehicles
  - Emphasis on silent ("quiet") watch
  - Unmanned vehicles (air/ground)
  - Inefficient management/ distribution of power
  - Demand for soldier-wearable power
- **Increased emphasis on system power metrics**
  - (KPPs, low consumption components)





OSD and Army Energy Goals

OSD S&T Strategy for Power & Energy

- Reduce platform energy consumption
- Smart energy management
- More efficient power sources
- Proactive thermal management
- Provide energy options

Army Energy Security Goals

- Reduce consumption
- Increase energy efficiency
- Increase use of renewable/ alternative energy
- Assured access to sufficient energy supplies
- Reduced adverse impacts on the environment

Army Power & Energy Focus Areas

- Vehicle Platform / System
- Soldier
- Forward Operating Base
- Installation

Operational Energy

Advanced Vehicle Power Technology Alliance

- Department of Defense and Department of Energy created an Energy Security MOU
- Advanced Vehicle Power Technology Workshop – Detroit, MI 18 & 19 July
  - 80 leaders from DA, DOE, industry and academia
  - Focus Areas:
    - Adv Combustion Engines & Transmissions
    - Lightweight Structures & Materials
    - Energy Recovery & Thermal Management
    - Alt Fuels & Lubricants
    - Hybrid Propulsion Systems & Batteries
    - Analytical Tools

- **Charter Signed 18 July** – Formed an alliance between the Department of Energy and the Department of Army in advanced vehicle power and energy technologies. The goal of the alliance is to leverage investments around common requirements and leverage industrial research and development to transition technologies and increase precompetitive R&D

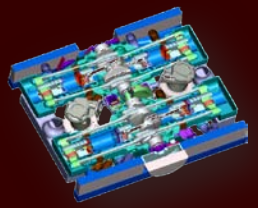
Advanced Vehicle Power Technology Solutions

U.S. ARMY RDECOM TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED. TARDEC

Vehicle Platform/System

Adv Combustion Engines and Transmissions

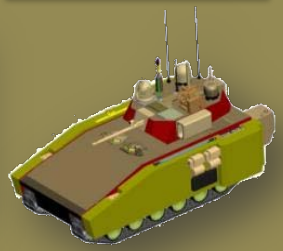
Efficient Powertrain Technologies



Next Generation Combat Engines

Combat Vehicle Auxiliary Power Units

Lightweight Structures and Materials

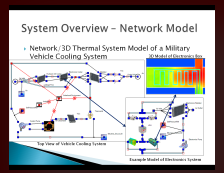


Advanced Combat Vehicle Armor

Tactical Vehicle Armor

Energy Recovery and Thermal Management

Exhaust System Thermoelectric Module



Thermal System Analysis and Optimization

Advanced Fan Systems

Alternative Fuels and Lubricants

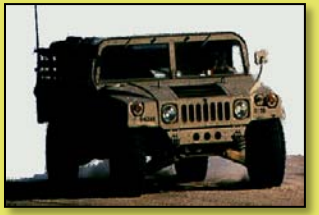
Synthetic and Renewable Fuels

Engine and Fuel System Qualification

Advanced Lubricants

Hybrid Propulsion and Batteries

Advanced Propulsion with Onboard Power

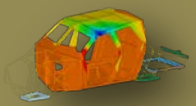


Hybrid Electric Vehicle Experimentation Assessment (HEVEA)

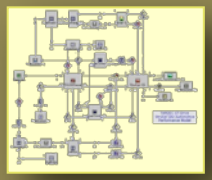
Advanced Li-ion Batteries

Analytical Tools

Crew compartment thermal modeling



Vehicle structural analysis



Powertrain simulation

Advanced Vehicle Power Technology Alliance – Key Technology Opportunities Examples

Adv combustion engines & transmissions	Lightweight structures & materials	Energy recovery & thermal management	Alternative fuels & lubricants	Hybrid Propulsion Systems	Analytical tools
Thermal Management	Establish Formal Methods for Exchanging Information	Thermo-electrics	More Fuel Efficient Oils and Lubricants	High Temp Inverters and Converters	Improved Multi-Dimensional Models
In-Cylinder Combustion Control and Sensors	Explore Weight Saving Impacts	Climate Control	Advanced Lubricant Additives	High Power/Energy Li-Ion	Standardization of M & S Processes and Metrics
Predictive Tools and Models	Holistic Design	Heat Transfer	More Fuel Efficient Hydraulic Fluids	Li-Air	Framework for Model Sharing
Fuel Injection System		Analysis and Optimization; Energy Balance	Specification Development	Lead Acid (Deep Charge)	
Advance Boosting Systems				Ultra Capacitors	

Ground Vehicle HEVEA Accomplishments

- Developed a Test Operating Procedure for HEV evaluation
- Performed Vehicle Testing:
  - Completed testing of 10 HEV and 10 Conventional vehicles for Fuel Economy and Performance Evaluations
  - Created a HEV and conventional vehicle database
  - Created a Test Incident Report (TIR) component reliability database
  - Developed approximately 200 statistical models predicting mean fuel economy
- Reports Completed:
  - Yuma Proving Grounds (YPG) Testing (December 2009)
  - Cold Regions Test Center (CRTC) Testing (August 2010)
  - Aberdeen Test Center (ATC) Testing (November 2010)
  - TARDEC Final Report (January 2011)
- Developed and validated Modeling and Simulation (M&S) Vehicle Propulsion System Evaluation Tool (VPSET)
- Defined 3 different missions using Duty Cycle Experiments (convoy, urban patrol, and mountain patrol) for South West Asia environment
- Developed a Fleet Maintenance Simulation Tool for Reliability Trade Studies

Ground Vehicle HEVEA Challenges

- **Reliability -** Reliability of HE technology in military environment not evaluated
  - Recommend HE technology needs to be fully evaluated
    - Several (5-7 minimum) pre-production military vehicles to accurately assess reliability data
    - Minimum 20,000 miles of testing data
- **Operational Analysis –** Value of HE technology attributes assessed under operational scenarios not evaluated
  - Recommend identify platform to gain greatest benefit from hybrid technology to assess logistics impact
    - Hybrid Technology may require different assessment due to greater capability
- **Cost Analysis** – Cost analysis of HE technology fuel savings versus cost incurred for a specific platform and related operational mode not evaluated
  - Cost vs. Hybrid additional capabilities
- **Life Cycle Cost Analysis** - Life cycle costs of new technology versus attributes to military not evaluated
  - Investment costs vs. life cycle costs due to fuel economy and capabilities (e.g. Replace generators)

These Challenges must be addressed to determine if Hybrid Electric Drive is Correct Investment for Army

Next Steps – Defining the Entry Point

Understanding Customer Profiles:

	Missions	
Current State	General Purpose	
	Surveillance	
	Convoy Iraq	
	Convoy Afghanistan	
	Urban Assault	
	Presence Patrol	
	Mobile Missile	
Future State	FOB – Network Energy	
	Patrol Base – grid Networked Vehicle	

	= Profile input received/relevant
	= Profile input not received

- **Contacted end-users**
  - 3rd ID, based out of FOB Echo, Iraq
  - 656th Transportation Company deployed to Afghanistan
  - USASOC
  - Cruise Missile Defense Systems Project Office
  - Non lethal weapons
- **Defined vehicle missions:**
  - Engine operating profile (from key-on to off)
  - Related to HEVEA cycles
  - Duration, speed, terrain
  - Vehicles used/types
  - Idle-time captured
- **Compiled data against HEVEA:**
  - Project fuel economy
    - Conventional
    - Hybrid
    - Hybrid w/anti-idle
  - Cost Benefit Model
- **User gap evaluation**

Conclusions

- **TARDEC recognizes the growing energy challenges of the Warfighter and is acting to meet the operational energy goals of the Army**
- **Research on advanced vehicle power technologies for vehicle platforms underway with collaborative efforts with other DOD labs as well as DOE**
- **Significant progress has been made in the area of hybrid electric propulsion analysis**
- **Hybrid electric propulsion strategically aligns with Operational Energy Strategy**
  - **Hybrid electric provides additional mission capabilities**
  - **Optimized hybrid electric can achieve fuel economy savings over various drive cycles**
  - **Reliability and Durability need to be proven**
  - **In the right applications:**
    - Has good Cost-Benefit
    - Provides capabilities not otherwise available
    - Fits customers need

It's All About the Warfighter